Improving Frost Forecasts for the Russian River Basin

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Frost Forecast Improvement

Objective 1 –

- **Supports rebuilding endangered Coho and threatened Chinook and steelhead stocks to sustainable levels through better management of the water used by vineyard operators to prevent frost damage.**

Frost Forecast Improvement

Objective 2 –

- **Directly improve frost forecast through utilization of a state of the science digital forecast system utilizing a very high resolution terrain resolving grid.**

- **The system learns the microclimates by ingesting in real-time hourly temperature and dewpoint data from over 50 vineyards within the Russian Basin. These data then determine the bias in forecast guidance that can be removed.**

- **Because it is a digital forecast system, every vineyard will have a local frost forecast twice daily with a lead time of from 15 hrs through 168 hrs.**

Frost Forecast Improvement

- Methodology to improve water management
  - Improve temporal and spatial forecasts to reduce hours or volume of watering
  - Increase lead time for frost occurrence to better manage water resources – reservoir ops, holding pond capacity, tributary flows, etc….
  - Promote alternative frost mitigation – fans or lower volume sprinklers
  - Disseminate to growers/water managers in form that they can use to make informed decisions.
  - Obtain additional temperature observations critical for improving forecast methodology

Development

- Builds off National Weather Service Graphical Forecast Editor used to generate all NWS forecast products last 12 years

- Current 2.5 km resolution NWS gridded forecasts too coarse to resolve vineyard microclimates

- Current NWS numerical forecast guidance too coarse to resolve topography and thus microclimates

- NWS developed a bias correction algorithm using available surface observations to "adjust" numerical guidance

- Applied this to frost forecast system utilizing real-time vineyard data made available through FarmEcology Labs, TerraSpace and Western Weather

- Partner with Western Wx-current contractor to Sonoma County Winegrape Commission- to help improve their forecasts
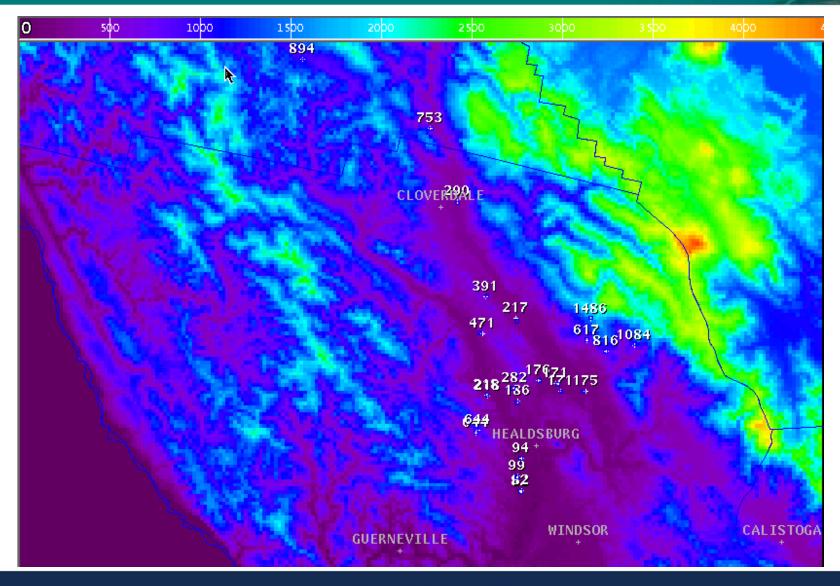
Timeline and Support

- 3 to 5 year project time horizon to begin to quantify benefits under the RRHB process
- Primary funding from Sonoma County Water Agency
  - Secondary funding from NOAA Office of Oceanic and Atmospheric Research and NOAA National Marine Fisheries (supports augmenting inversion towers with real-time capability – contribution from RRHB)
  - Strongly supported by Sonoma County Winegrape Commission – aided in getting RT observations from vineyards
  - NWS San Francisco Bay Area providing their forecast as well as statistical guidance and observations
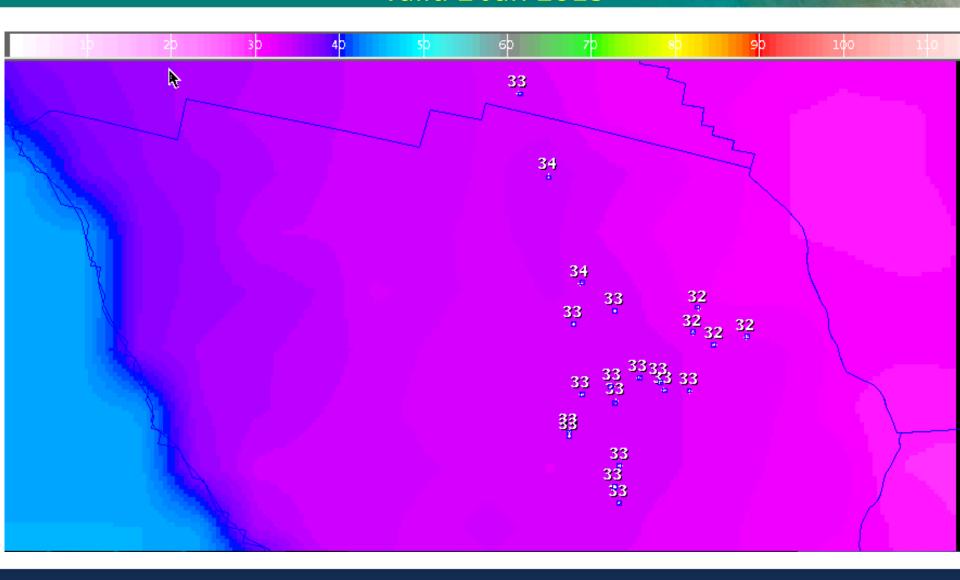
Alternative Solutions for Frost Mitigation

- Will partner with UC Coop Extension 's (UCCE) Temperature Inversion Study to differentiate between days when fans versus sprinklers can be used to mitigate frost damage.

- NOAA would provide real-time access to the inversion information to growers via web site.
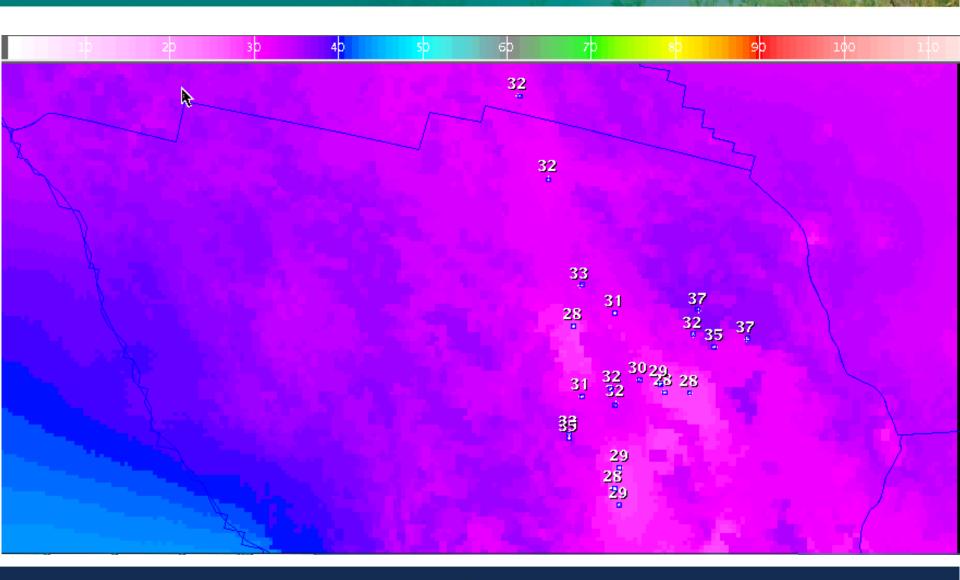
Frost Project 250 m topography grid with 22 of the 52 vineyard real-time data locations with station elevation (ft)
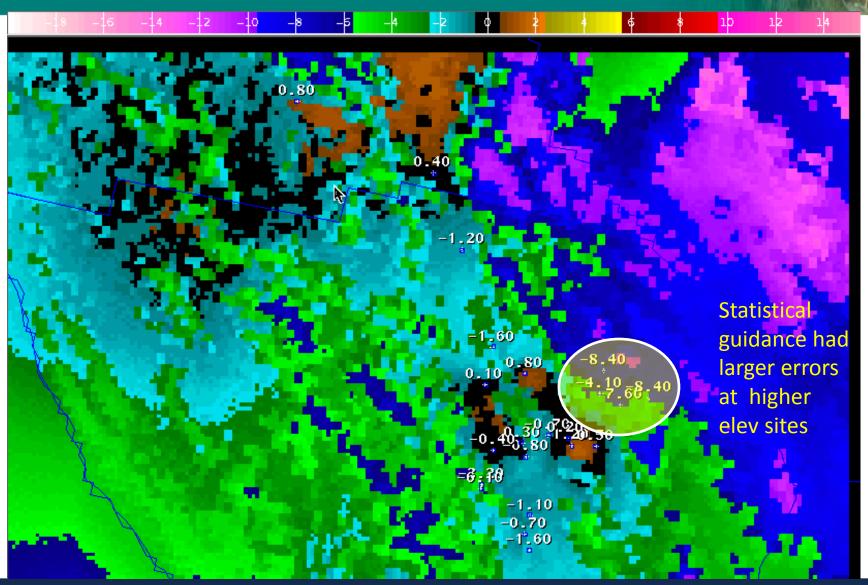
Raw Statistical Guidance
MinT Forecast for grid point nearest the vineyard location
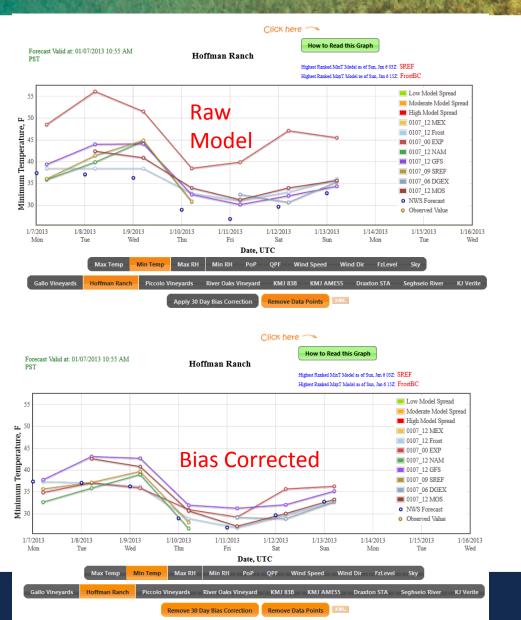valid 2 Jan 2013

www.noaa.gov

Bias Corrected Statistical Guidance valid 2 Jan 2013

Spatial view of 15 hr forecast error for "Best Guidance" Jan 2 2013

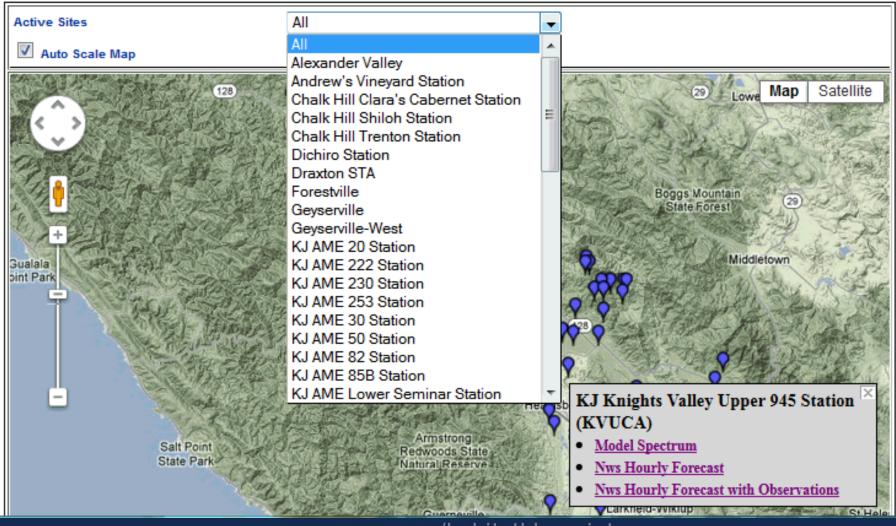Statistical guidance had larger errors at higher elev sites

Output Products for Viewing

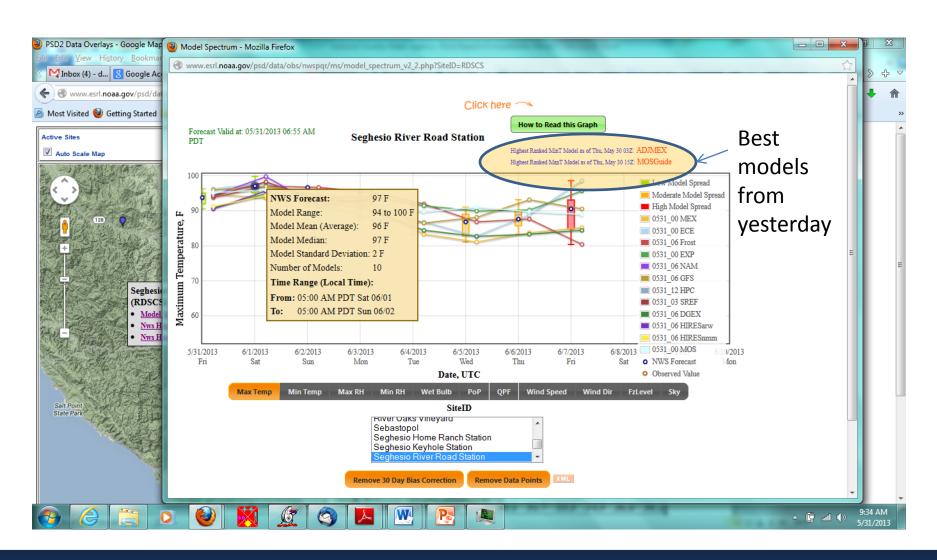
Model Spectrum page showing plot of available numerical and statistical minimum temperature forecasts along with NWS "official" forecast.

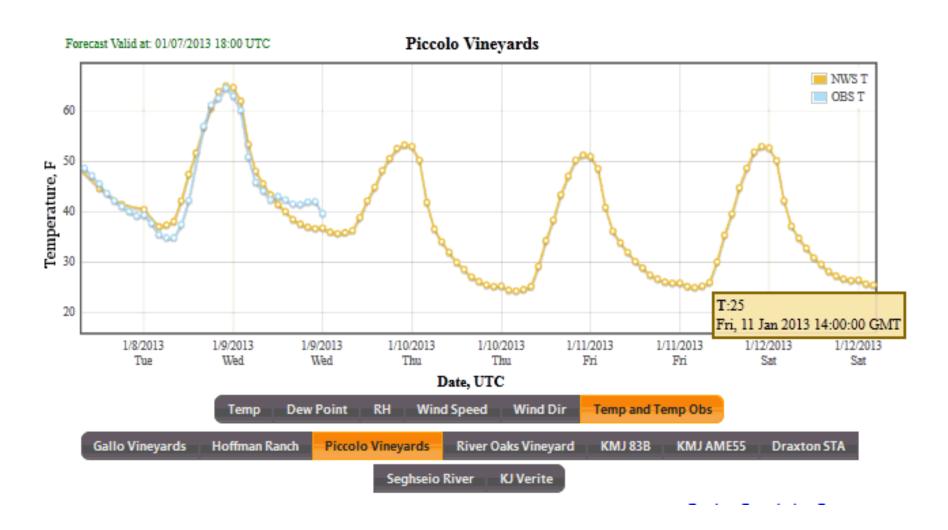# Google Map of Vineyard Frost Forecasts

- http://www.esrl.noaa.gov/psd/data/obs/nwspqr/map/WineryMap.php

Mouse over NWS Point to see Model Spread and Stats

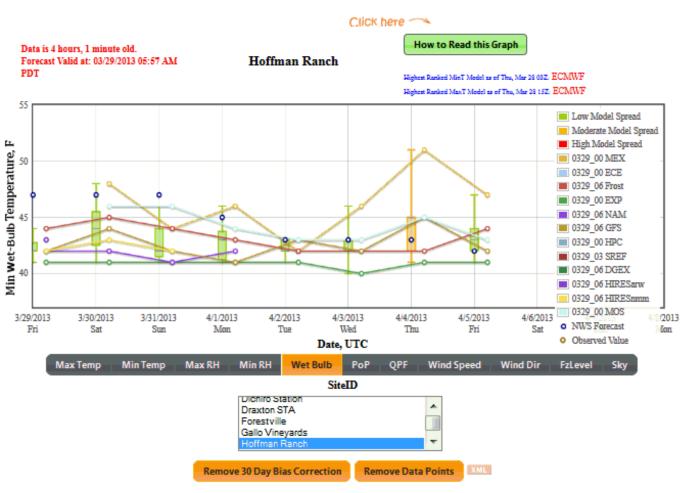# Developing Diurnal Trends from Observations to Determine Duration of Low or High Temperatures

Table 3. Minimum turn-on and turn-off air temperatures (°F) for sprinkler frost protection for a range of wet-bulb and dew-point temperatures (°F)*

Dew-point Temperature °F	Wet-bulb Temperature (°F)										
	22	23	24	25	26	27	28	29	30	31	32
32											32.0
31										31.0	32.7
30									30.0	31.7	33.3
29								29.0	30.6	32.3	34.0
28							28.0	29.6	31.2	32.9	34.6
27						27.0	28.6	30.2	31.8	33.5	35.2
26					26.0	27.6	29.2	30.8	32.4	34.0	35.7
25				25.0	26.5	28.1	29.7	31.3	32.9	34.6	36.3
24			24.0	25.5	27.1	28.6	30.2	31.8	33.5	35.1	36.8
23		23.0	24.5	26.0	27.6	29.1	30.7	32.3	34.0	35.6	37.3
22	22.0	23.5	25.0	26.5	28.1	29.6	31.2	32.8	34.5	36.1	37.8
21	22.5	24.0	25.5	27.0	28.5	30.1	31.7	33.3	34.9	36.6	38.2
20	22.9	24.4	25.9	27.4	29.0	30.6	32.1	33.7	35.4	37.0	38.7
19	23.4	24.9	26.4	27.9	29.4	31.0	32.6	34.2	35.8	37.5	39.1
18	23.8	25.3	26.8	28.3	29.8	31.4	33.0	34.6	36.2	37.9	39.5

* Select a wet-bulb temperature that is at or above the critical damage temperature for your crop and locate the appropriate column. Then choose the row with the correct dew-point temperature and read the corresponding air temperature from the table to turn your sprinklers on or off. This table assumes a barometric pressure of 1013 millibars (101.3 kPa).

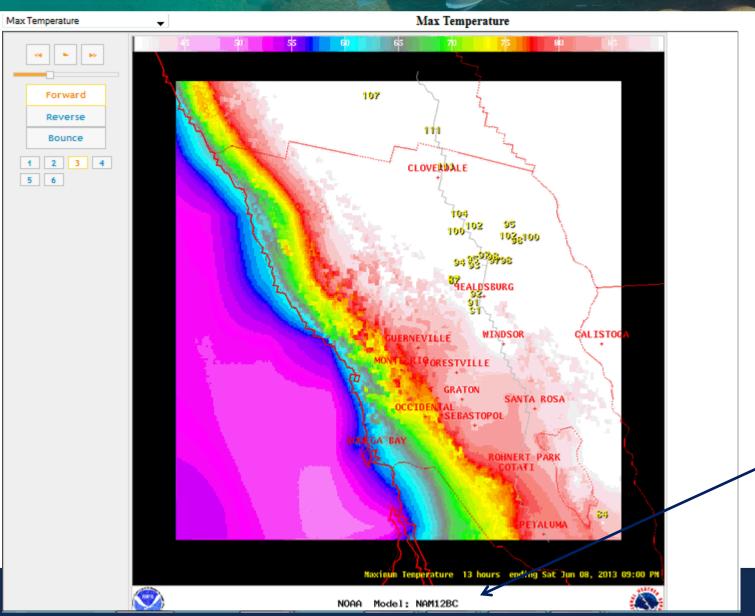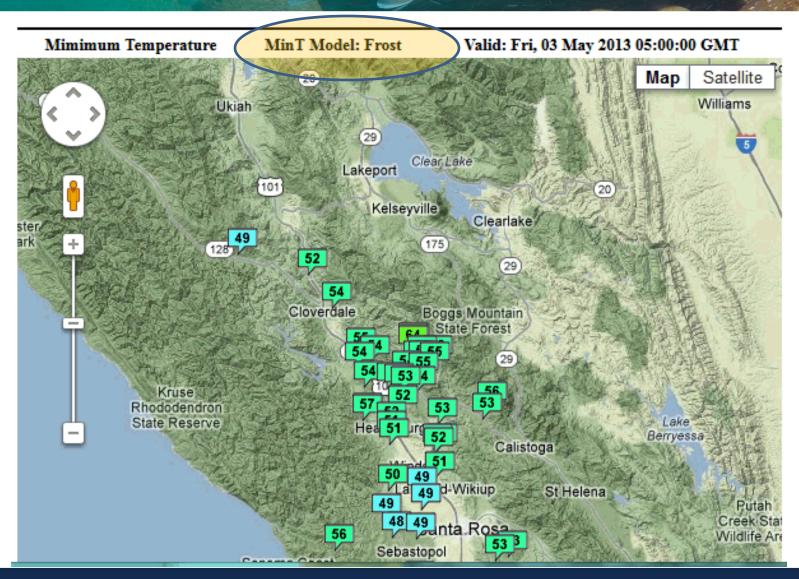# MinTw now calculated from MinT and MaxRh from each model and Obs

Animation Page

- http://www.esrl.noaa.gov/psd/data/obs/nwspqr/anim/Loops.php

Best Model from previous day

Google Map of Tomorrow's MinT

www.noaa.gov/habitatblueprint

MinT and MaxT Verification sent to Western Wx and myself Daily

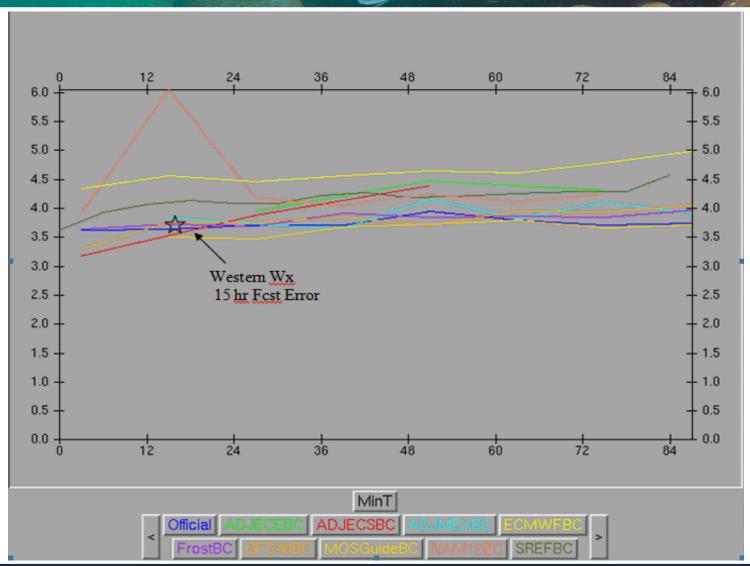## MinT Verification Summary for Fri, Jan 4:

Grid Time: start: Fri, Jan 4 03Z end: Fri, Jan 4 17Z
Edit Area: Wineries3 (22 gridpoints)

Measures of Difficulty:

Avg Anomaly: -5.87   Avg |anomaly|: 6.80 Rank: 9 out of last 30
Avg 24hr Chg: +3.84   Avg |24hr Chg|: 3.84 Rank: 15 out of last 30
Standard Deviation: 4.39 Rank: 5 out of last 30

Period	Forecast Made	Made by	Official MAE	Official Bias	Official Percent >10° Err	Official Percent <3° Err	Official Rank among Guidance	Best Guidance	2nd Best Guidance	Worst Guidance
1 15-hr Thu	1/ 3 day	unknown	1.90	0.82	0.0%	81.8%	2 out of 15	ADJMEXBC 90.9%	MOSGuideBC 72.7%	ECMWF 4.5%
2 27-hr Thu	1/ 3 mid	unknown	4.25	3.25	0.0%	22.7%	7 out of 15	ADJMEXBC 90.9%	GFS40BC 77.3%	ECMWF 0.0%
3 39-hr Wed	1/ 2 day	unknown	2.77	2.02	0.0%	54.5%	5 out of 13	ADJMEXBC 90.9%	MOSGuideBC 68.2%	NAM12 0.0%
4 51-hr Wed	1/ 2 mid	unknown	2.18	1.20	0.0%	63.6%	4 out of 15	ADJMEXBC 86.4%	ADJMEX 68.2%	ECMWF 0.0%
5 63-hr Tue	1/ 1 day	unknown	2.14	1.16	0.0%	68.2%	4 out of 13	ADJMEXBC 90.9%	FrostBC 81.8%	SREF 9.1%
6 75-hr Tue	1/ 1 mid	unknown	1.99	-0.10	0.0%	81.8%	2 out of 17	ADJMEXBC 90.9%	FrostBC 72.7%	ECMWF 0.0%
7 87-hr Mon	12/31 day	unknown	4.49	3.76	0.0%	18.2%	12 out of 17	ADJMEXBC 86.4%	HPCGuideBC 68.2%	ECMWF 0.0%
8 99-hr Mon	12/31 mid	unknown	4.99	4.43	0.0%	22.7%	9 out of 15	ADJMEXBC 72.7%	ADJMEX 63.6%	ECMWF 4.5%
9 111-hr Sun	12/30 day	unknown	4.35	3.76	0.0%	36.4%	6 out of 15	DGEXBC 63.6%	ADJMEXBC 63.6%	ECMWF 4.5%
10 123-hr Sun	12/30 mid	unknown	3.31	1.62	0.0%	45.5%	4 out of 13	ADJMEX 68.2%	FrostBC 63.6%	ECMWF 4.5%
11 135-hr Sat	12/29 day	unknown	2.43	0.36	0.0%	68.2%	2 out of 15	DGEXBC 90.9%	HPCGuideBC 50.0%	ECMWF 9.1%
12 147-hr Sat	12/29 mid	unknown	2.76	1.60	0.0%	54.5%	3 out of 15	HPCGuideBC 77.3%	FrostBC 68.2%	ECMWF 4.5%
13 159-hr								HPCGuideBC 50.0%	HPCGuide 36.4%	ECMWF 4.5%
14 171-hr								ADJMEX 40.9%	GFS40 36.4%	ECMWF 4.5%

Average over past 30 days:

Period			Official MAE	Official Bias	Official Percent >10° Err	Official Percent <3° Err	Official Rank among Guidance	Best Guidance	2nd Best Guidance	Worst Guidance
1 15-hr			3.72	1.2	2.3%	48.3%	10 out of 15	ADJMEXBC 69.2%	NAM12BC 61.7%	ECMWF 14.9%
2 27-hr			3.60	1.1	2.6%	49.4%	8 out of 15	ADJMEXBC 59.1%	MOSGuideBC 58.6%	ECMWF 9.7%
3 39-hr			4.25	1.7	6.6%	44.8%	10 out of 15	ADJMEXBC 66.9%	MOSGuideBC 56.5%	ECMWF 11.3%
4 51-hr			4.09	1.7	6.4%	45.0%	10 out of 15	ADJMEXBC 66.4%	ADJMEX 55.4%	ECMWF 8.9%
5 63-hr			4.28	1.7	7.3%	43.8%	10 out of 15	ADJMEXBC 66.5%	ADJMEX 58.5%	ECMWF 10.3%
6 75-hr			4.16	1.7	5.7%	42.7%	9 out of 17	ADJMEXBC 59.1%	ADJMEX 56.3%	ECMWF 6.2%

MinT Mean Absolute Error as Function of Forecast Lead Time
March 15 - May 15 2013 (2 sites)

UCCE Temperature Inversion Study

- **Purpose:** Assess springtime inversion conditions to determine suitability of wind machines for frost protection throughout coastal vineyard regions
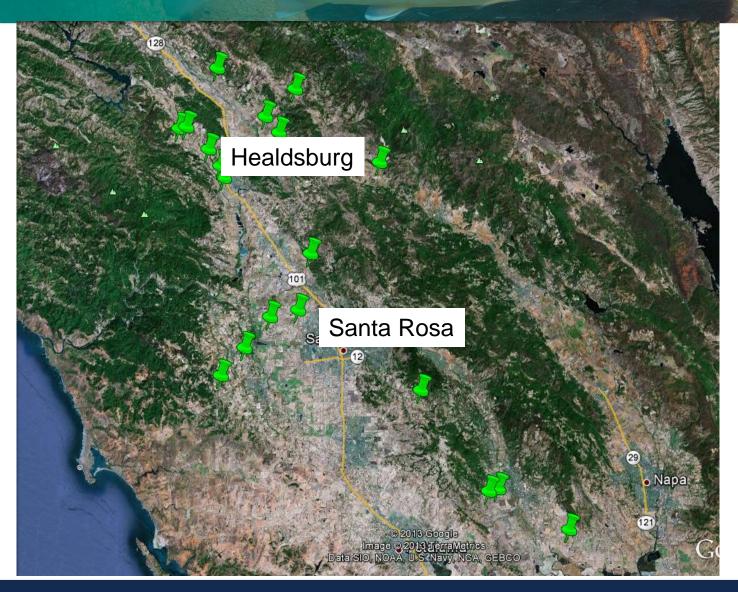
- **Team:**
  - Mark Battany, Farm Advisor
  - Gwen Tindula, Staff Research Associate
  - Rhonda Smith, Farm Advisor
  - Rick Snyder, Biometeorology Specialist

- **Funding:** American Vineyard Foundation (2011) and CDFA Specialty Crops Block Grant (late 2011)
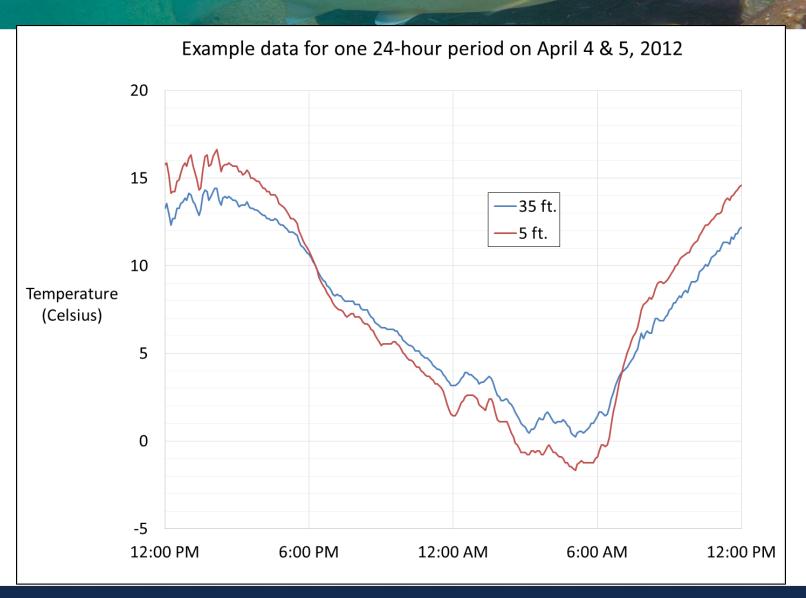
UCCE Temperature Inversion Study

- 60+ towers in vineyard regions of three counties: Sonoma, San Luis Obispo, Santa Barbara

- Conducted during spring of 2012, 2013 and 2014

- Air temperature measured at 5 ft. and 35 ft. heights using small Hobo data loggers mounted on flexible masts
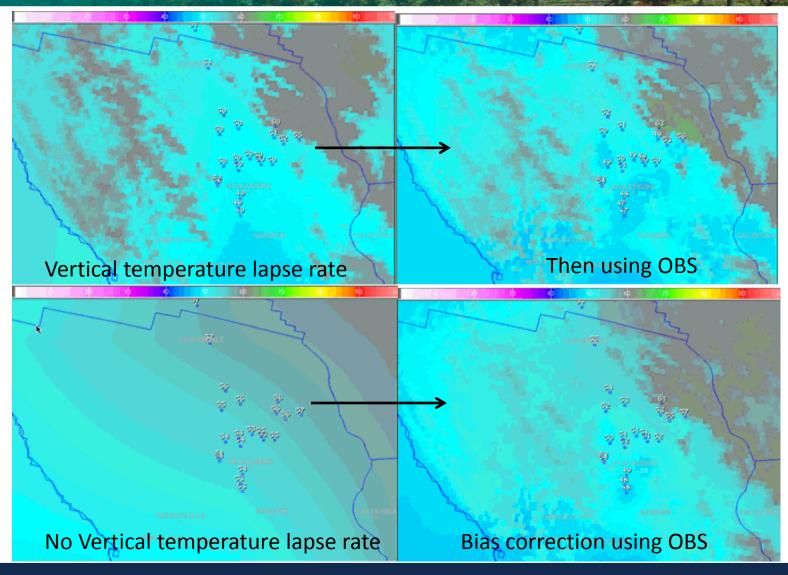
Sonoma County 2012 tower locations

Healdsburg

Santa Rosa

Example of Tower Data During Inversion

Example data for one 24-hour period on April 4 & 5, 2012

Conclusions

- Prototype frost/heat forecast system shows skill out through day 3 in forecasting potential frost/heat stress on grape plants.
  - Because it is digital and run at 250 m resolution can provide forecast guidance for anywhere in the domain
- Verification shows that statistical post-processed model guidance further bias corrected using real-time vineyard temperature data provides the best forecast
  - When there is a sudden and significant air-mass change the prototype bias correction may not be useful. Unbiased statistical post-processed model guidance may prove most useful in these cases
- Obtaining additional real-time vineyard data should improve forecasts for those vineyards not currently providing data
- Need to evaluate tower data to determine its utility in quantifying fans versus water for frost mitigation
- **Critical step - how best to communicate the forecasts to growers and water managers in a way that will inform current mitigation practices during frost/heat events to improve water management in Russian R. and its tributaries**

Two methods of Downscaling

Vertical temperature lapse rate

Then using OBS

No Vertical temperature lapse rate

Bias correction using OBS

Max Temperature Forecast June Heat